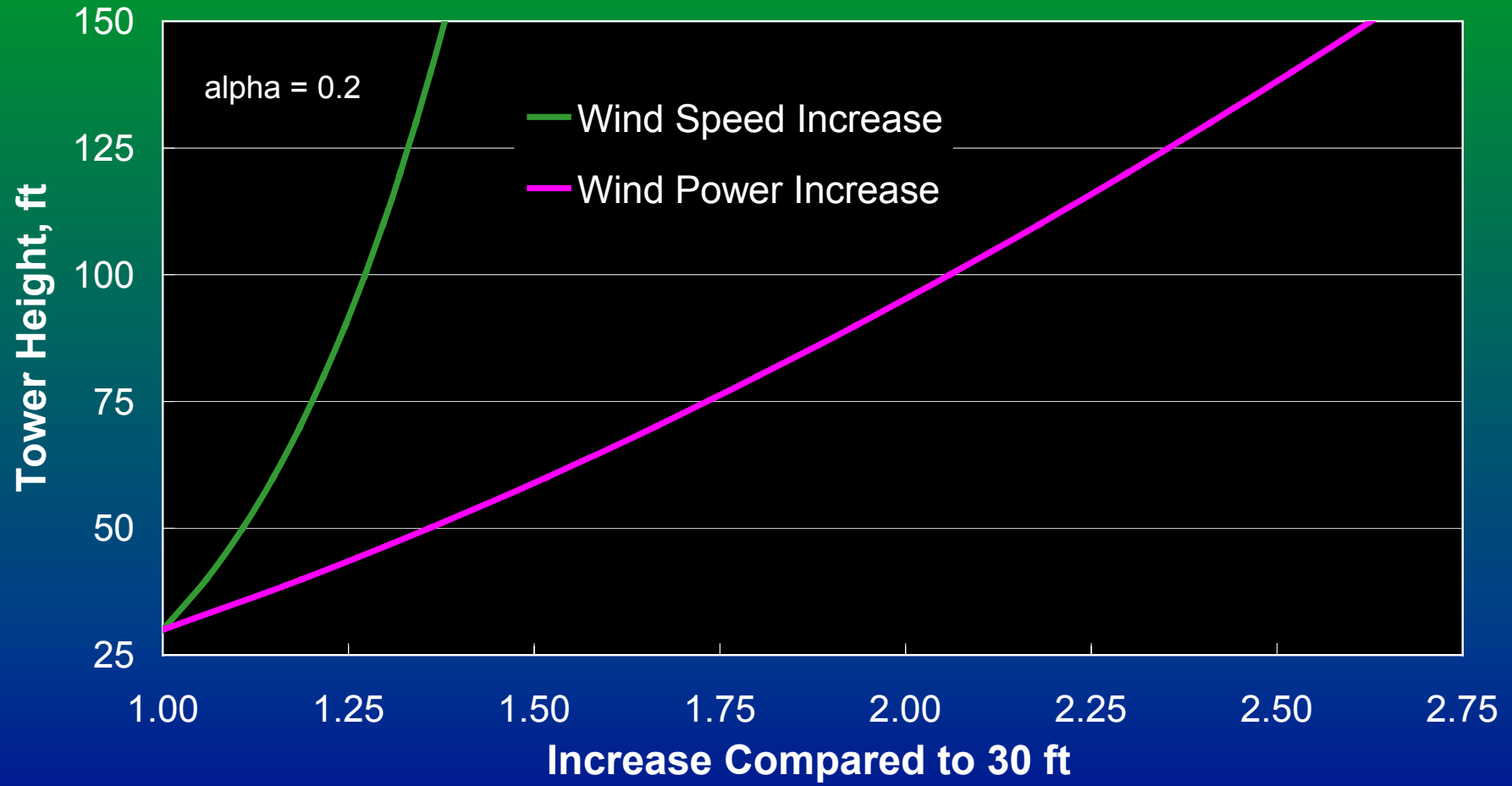
How Wind Works?

- Wind energy is created by uneven heating of the earth's surface.
- Wind energy is kinetic energy — mass and momentum.

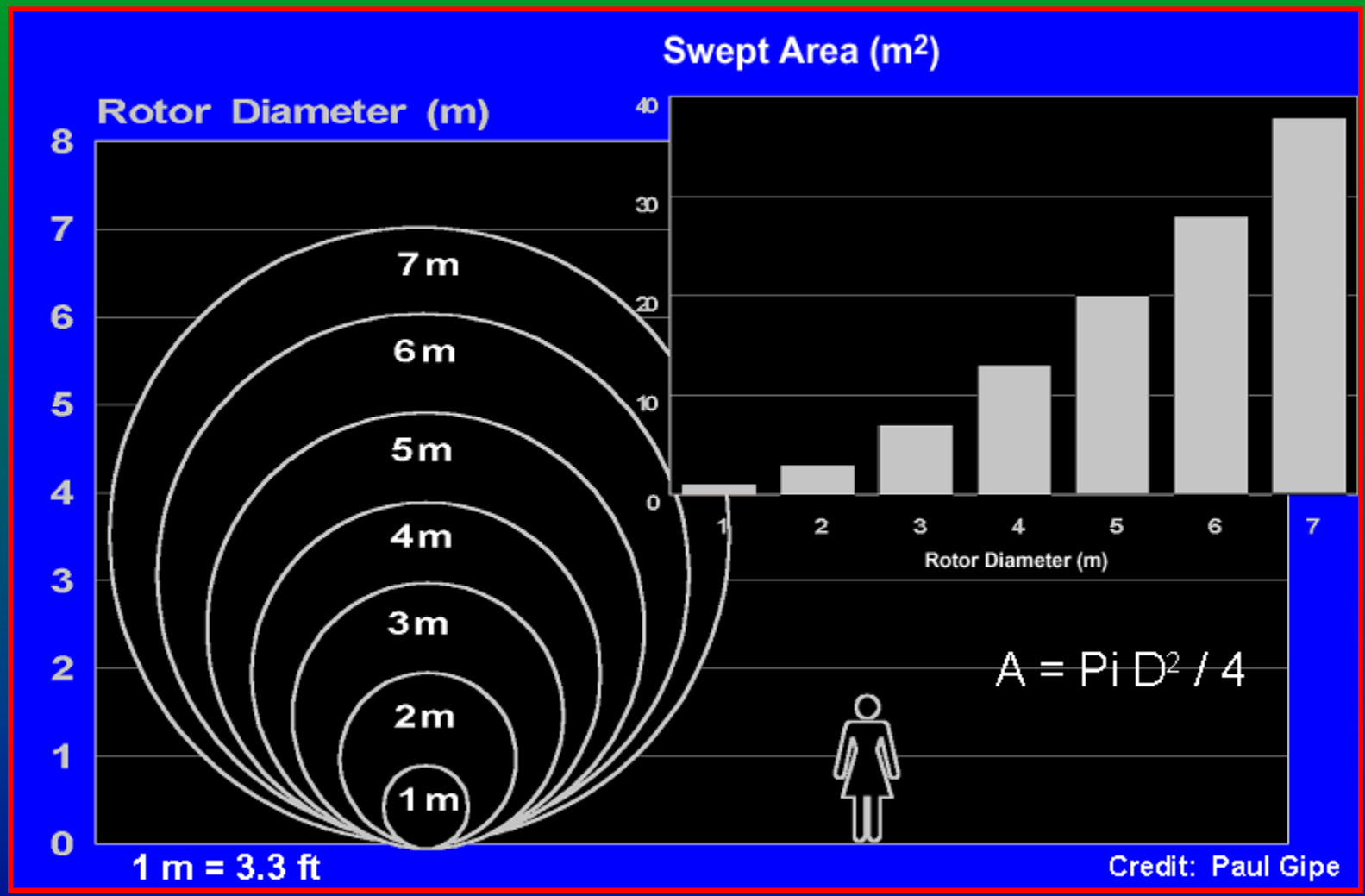
Calculation of Wind Power

- Power in the wind = $k \frac{1}{2} \rho A V^3$
  - Effect of wind speed, V
  - Effect of swept area, A
  - Effect of air density, ρ
  - Constant for units conversion, k
    - [English units]
    - [SI units]

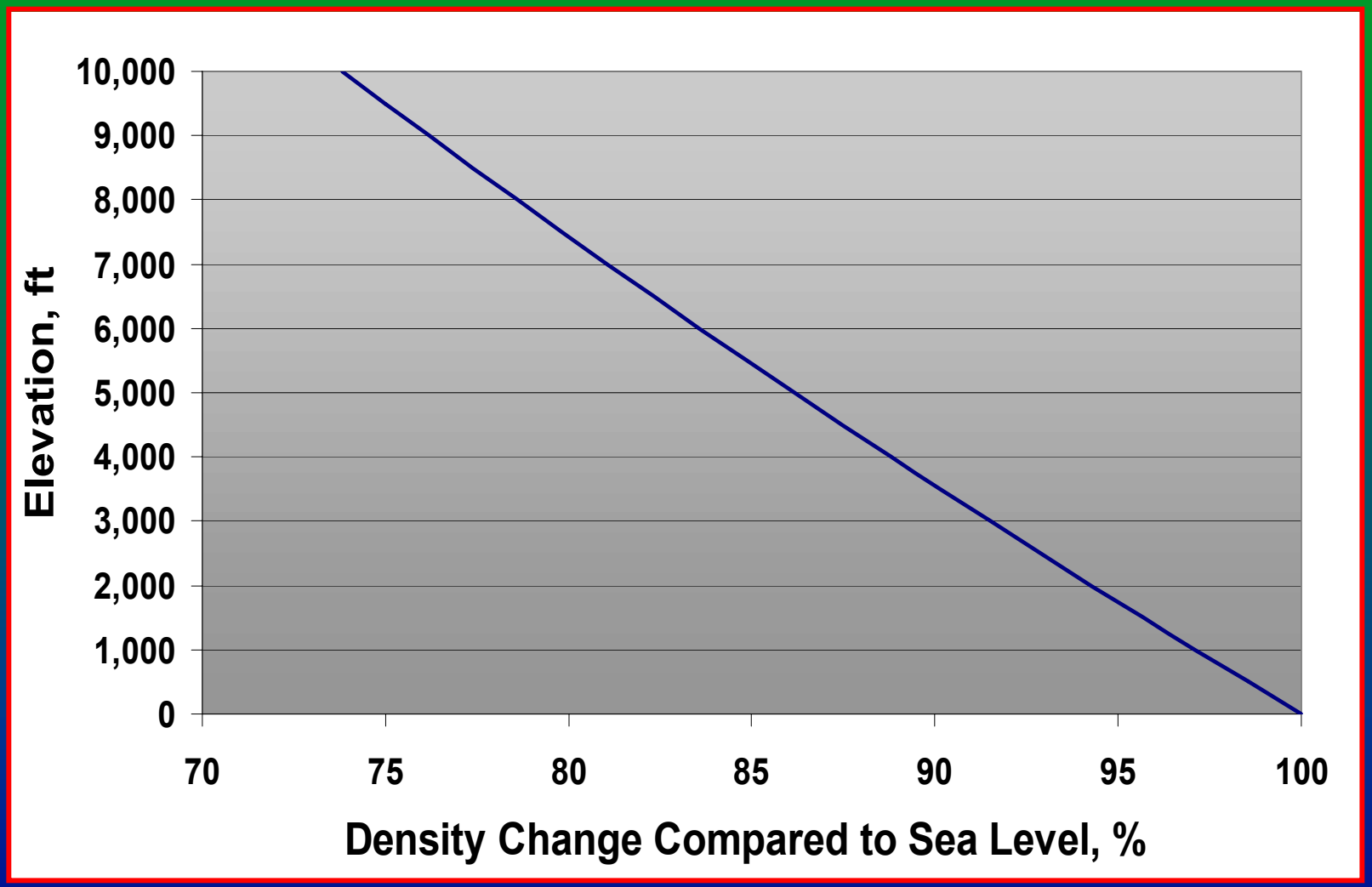
Wind Speed and Power Increase with Height Above the Ground



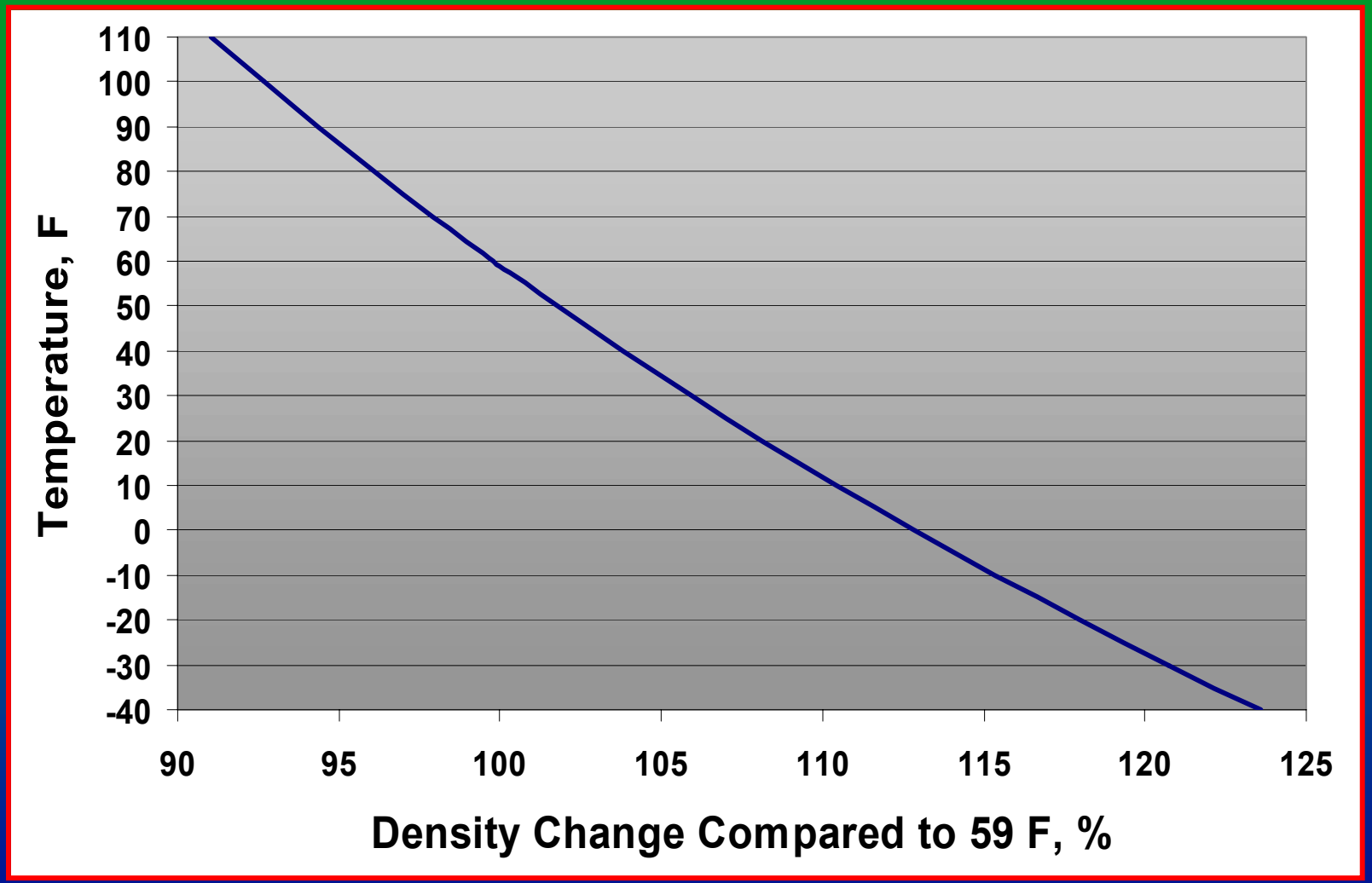
Relative Size of Small Wind Turbines



Air Density Changes with Elevation



Air Density Changes with Temperature



Calculation of Wind Power

- Power in the wind = $k \frac{1}{2} \rho A V^3$
  - Effect of wind speed, V
  - Effect of rotor diameter on swept area
    $A = Pi\ D^2 / 4$
  - Effect of elevation and temperature on air density, ρ

Calculation of Wind Turbine Power

- Power from a wind turbine = C_p k ½ ρ A V^3
  - Effect of wind speed, V
  - Effect of rotor diameter on swept area
    A = Pi D^2 / 4
  - Effect of elevation and temperature on air density, ρ
  - Power coefficient (efficiency), C_p up to ~0.35 for small wind turbines (theoretical max = 0.59)

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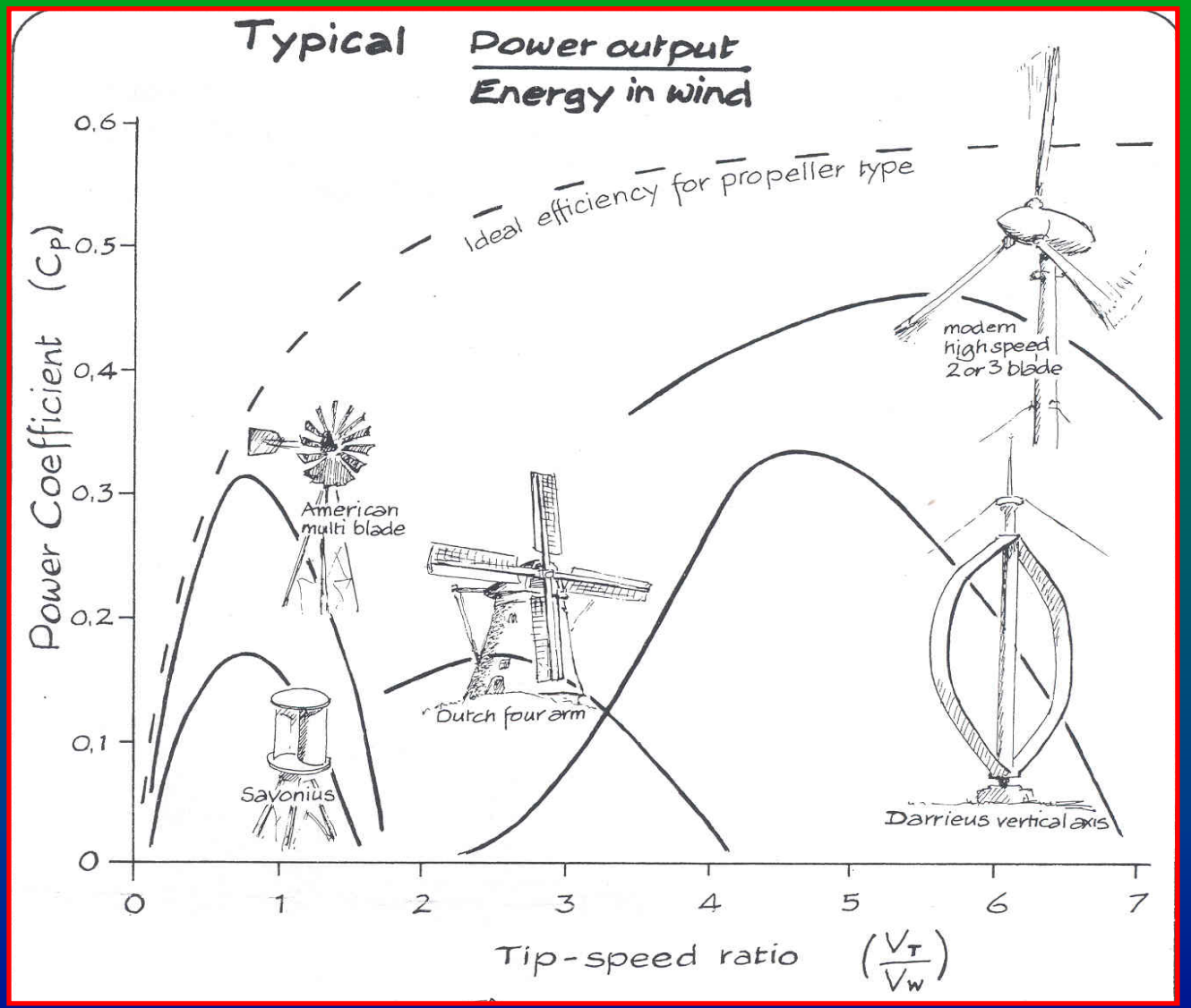
Wind Machine Types



Wind Turbine Power Curve

Southwest Windpower AIR 403

Calculation of Wind Power
SI Units

Power in the wind = $k \frac{1}{2} \rho A V^3$

- P – power, kW
- k = 0.001 = $^1/_{1000}$
- ρ – air density, kg/m^3 (1.225 kg/m^3 at sea level)
- A – swept area, m^2
- V – wind speed, m/s

- P – power, W
- k = 1.0
- ρ – air density, kg/m^3 (1.225 kg/m^3 at sea level)
- A – swept area, m^2
- V – wind speed, m/s

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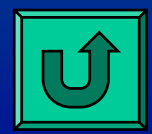
Calculation of Wind Power
English Units

Power in the wind = $k \frac{1}{2} \rho A V^3$

- P – power, kW
- k = 0.000133
- ρ – air density, lb/ft^3 (0.07647 lb/ft^3 at sea level)
- A – swept area, ft^2
- V – wind speed, mph

- P – power, hp
- k = 0.000178
- ρ – air density, lb/ft^3 (0.07647 lb/ft^3 at sea level)
- A – swept area, ft^2
- V – wind speed, mph



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